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(54) **Metallic local reinforcement for heavy loaded joints of composite components**

(57) A mechanically fastened joint having at least two parts (21, 23) of a composite material, preferably carbon fibres impregnated with thermoset resin, with continuous plies along the joint areas (25, 27) and a metal reinforcement, preferably made of titanium, in the joint area (25, 27), the joint area (25, 27) thickness being increased in the thickness of said reinforcement. The metal reinforcement may consist of one or more metal foils or sheets (31) interleaved between the composite parts (21, 23) plies or one or more metal plates (33) embedded between two of the composite parts (21, 23) plies.

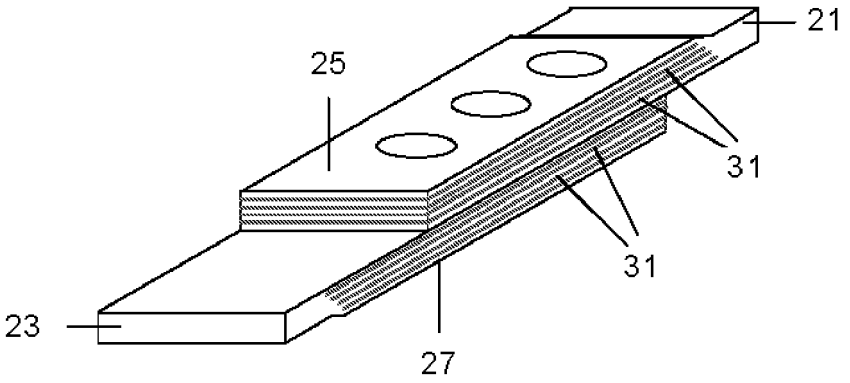

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention refers to a structural concept of hybrid joint consisting of metallic foils, sheets or plates locally embedded into a composite part.

[0002] A preferred application of the hybrid reinforcement is to strengthen heavy loaded bolted joints, fittings or other complex three-dimensional parts of an aircraft.

BACKGROUND OF THE INVENTION

[0003] Modern history of hybrid Fibre/Metal materials starts on the early eighties: Delft University of Technology introduced ARALL (an Aramid/Aluminium Fibre Metal Laminate -FML-) in 1981. Later, Delft-TU together with Fokker Aerospace developed GLARE (Glass Fibre/Aluminium FML), solving structural limitations that prevented a wide use of ARALL. This has been shown with the introduction of GLARE as replacement of monolithic aluminium on some parts of the largest passenger aircraft program, the A380, in 2001.

[0004] For other applications, different combinations of materials could be more suitable. In this context, Boeing research programs dealing with Titanium/CFRP (Carbon Fibre Reinforced Plastic) FML during the development of the High Speed Civil Transport (HSCT) is an example: sandwich material made of IM7/PIXA (thermoplastic resin) core with titanium facesheets as high temperature and fatigue resistant material. Also to be applied on the same HSCT program, The Boeing Company issued in 1999 the patent US 5,866,272 (Titanium-Polymer Hybrid Laminates), where a symmetric hybrid laminate consisting of a central honeycomb core with a number of titanium foils and carbon layers is described.

[0005] In parallel, NASA-Langley Research Center performed investigations, also to be applied to a HSCT aircraft, with FML consisting of IM7 carbon tapes (polyamide thermoset resin) with Ti-15V-3Cr-3Al-3Sn foils. Different titanium surface treatments were examined (Report Ref. NASA-98-21amas-wsj).

[0006] As example of a different application, the German Aerospace Centre (DLR - Deutches zentrum fur Luft und Raumfahrt) proposed in 2003 a concept for the transition of a full-CFRP part to a hybrid Ti/CFRP one by progressively replacing most of the carbon tapes by titanium foils in a certain patented manner called "Lamella Coupling System" (WO00/56541, 28th September 2000). The reinforced region results in having Ti foils combined with some of the original 0° plies. Prepregs used were Ciba 6376C-HTA/HTS mixed with Ti-6AI-4V alloy sheets.

[0007] A common issue with all fibre/metal materials is the required surface treatment to be applied to the metal to ensure a proper bonding to the composite or to the adhesive layer if exists. With new regulations, old and complex pollutant methods containing high levels of Volatile Organic Compounds (VOC) are no longer allowed. After a joint program involving the US Air Force, the US Navy, the US Army and US Industry Department under a SERDP (Strategic Environmental Research and Development Program) Project numbered PP-1113, the Boeing Company selected the so-called Boegel-EPII as the most promising low-VOC surface treatment technology for titanium bonding. This product is commercially available as AC™ - 130, from Advanced Chemistry & Technology, Garden Grove, CA.

[0008] A common practice to ensure proper load transfer on current aircraft primary composite structures' heavy loaded joints is to thicken the laminate with additional plies until the required strength is achieved. With this, thickness of the joint can be significantly increased, as thus the weight will do.

[0009] The present invention is intended to solve this drawback.

SUMMARY OF THE INVENTION

[0010] The present invention proposes a mechanically fastened joint having at least two composite parts, characterized in that the plies of the composite parts are continuous along the joint areas and in that at least one of said composite parts has a metal reinforcement in the joint area, the joint area thickness being increased in the thickness of said reinforcement.

[0011] The present invention embodies in particular a new application of metal on full composite parts as local reinforcement to reduce bolted joint structural weight and thickness. Internal Airbus España research has demonstrated that, on heavy loaded bolted joints, interleaving one or more foils, sheets or plates of metal, particularly titanium, into the composite part allow a local optimisation. Such optimisation is traduced onto weight and thickness reduction of the joint, with subsequent eccentricity decrease what improves carbon composite joint performance.

[0012] A basic characteristic of this invention is that carbon plies are not interrupted along the reinforcement, ensuring a proper load transfer. Ti foils replace the additional CFRP lamina that would have been necessary to strengthen and thicken up the bolted joint on a full CFRP joint.

[0013] Other characteristics and advantages of the present invention will be clear from the following detailed description of embodiments illustrative of its object in connection with the attached figures.

DESCRIPTION OF THE DRAWINGS

[0014]

Figure 1 shows a sketch of a typical full CFRP reinforcement on a bolted joint between two carbon fibre parts.

Figure 2 shows a sketch of a bolted joint reinforced

with several titanium foils interleaved in both parts. Figure 3 shows a sketch of a bolted joint reinforced with a titanium plate embedded in both parts.

DETAILED DESCRIPTION OF THE INVENTION

[0015] In known heavy loaded joints having two composite parts 11, 13 both parts are thickened with additional plies until the required strength is achieved, resulting in a reinforced area (15,17).

[0016] In the first embodiment of the invention shown in Fig. 2, the two composite parts 21, 23 have several titanium foils 31 interleaved as reinforcement into the carbon fibre laminates.

[0017] In the second embodiment of the invention shown in Fig. 3, the two composite parts 21, 23 have one titanium plate 33 embedded as reinforcement into the carbon fibre laminates.

[0018] By interleaving the foils 31 or embedding the plates 33, a thickness increase is created on the joint areas 25, 27. However, the eccentricity is notably reduced when comparing to the full CFRP reinforced joint shown in Figure 1.

[0019] The amount of the titanium foils in at least one of the composite parts 21, 23 will be fixed when sizing the parts during the design phase, whereas the thickness of the foils to be used will need a compromise between stress requirements, manufacturing restrictions and supplier availability. Therefore, depending on the kind of part, manufacturing process and/or supplier, titanium foils or sheets ranging from tenths of a millimetre to plates of several millimetres could be used.

[0020] Intermediate Modulus (IM) or High Strength (HS) carbon fibres impregnated with thermoset resin are the preferred materials for the composite parts 21, 23. Any other kind of carbon and / or other fibres (glass, aramid, boron, basalt, etc.), and / or other resin systems, such as thermoplastic (TP) or bismaleimide (BMI) for example, and / or other metals (aluminium, steel, magnesium, etc.) are also suitable to take advantage of this structural concept.

[0021] Titanium is the preferred material for the metal reinforcement. Ti sheets selected were pre-treated and delivered ready to be added to the composite parts.

[0022] The reinforcement consisting on Titanium foils, sheets or plates is placed during the lamination, keeping internal Airbus rules for ply drop-off for the transition from full CFRP to hybrid CFRP/Ti, whether it is performed by means of ATL, or FP machines, hand laid-up or other prepreg processing technology.

[0023] Eventually, adhesive layers could or not be needed between the composite plies and the titanium foils, sheets or plates.

[0024] Titanium foils, sheets or plates could also be used on parts manufactured by means of dry textile injection/infusion technologies (RTM, RFI, LRI, etc.), taking into account the specificities of those processes.

[0025] Bolts, rivets or any kind of fastener are suitable means for mechanically fasten the joint.

[0026] Modifications may be introduced in the preferred embodiment just set forth, which are comprised within the scope defined by the following claims.

Claims

1. A mechanically fastened joint having at least two composite parts (21, 23), **characterized in that** the plies of the composite parts (21, 23) are continuous along the joint areas (25, 27) and **in that** at least one of said composite parts (21, 23) has a metal reinforcement in the joint area (25, 27), the joint area (25, 27) thickness being increased in the thickness of said reinforcement.

2. A mechanically fastened joint having at least two composite parts (21, 23) according to claim 1, **characterized in that** said metal reinforcement consists of one or more metal foils or sheets (31) interleaved between the composite parts (21, 23) plies.

3. A mechanically fastened joint having at least two composite parts (21, 23) according to claim 1, **characterized in that** said metal reinforcement consist of one or more metal plates (33) embedded between two of the composite parts (21, 23) plies.

4. A mechanically fastened joint having at least two composite parts (21, 23) according to any of the preceding claims, **characterized in that** the composite parts are made of Intermediate Modulus (IM) or High Strength (HS) carbon fibres impregnated with thermoset resin.

5. A mechanically fastened joint having at least two composite parts (21, 23) according to any of the preceding claims, **characterized in that** the metal reinforcement is made of titanium.

6. A mechanically fastened joint having at least two composite parts (21, 23) according to any of the preceding claims, **characterized in that** the fasten means are bolts.

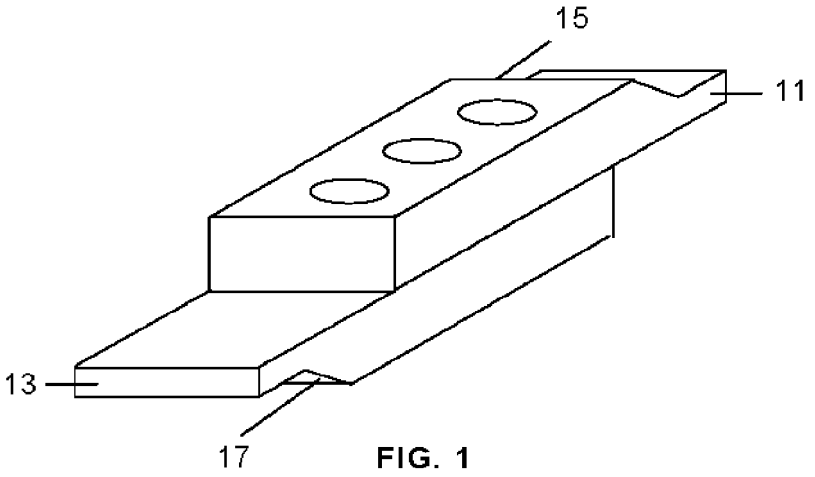

FIG. 1

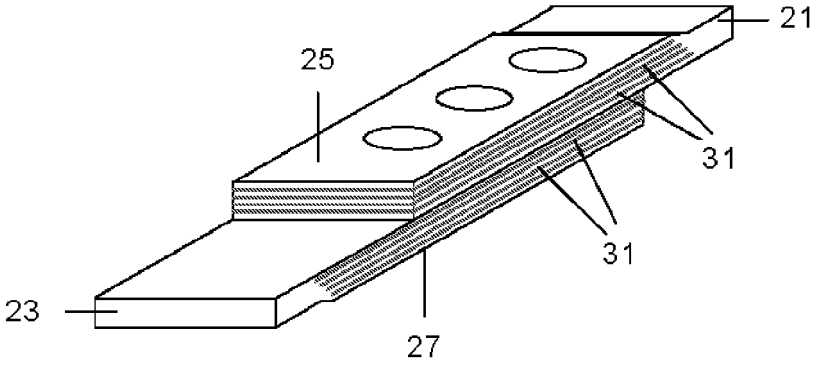

FIG. 2

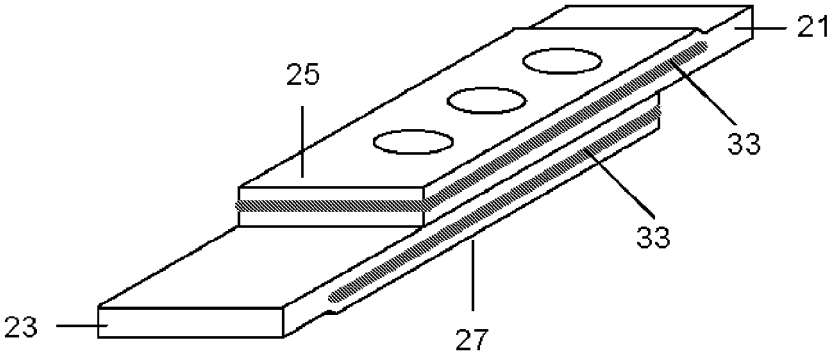

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 05 38 1062

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 1 081 154 A (METALLWERK A.-G. BUCHS) 31 August 1967 (1967-08-31) * page 1, lines 14-17,37-39,44-48; figure 1 * -----	1-6	INV. F16B5/00 B29C65/56 ADD. B64C1/00 B29K101/10 B29K101/12 B29K307/04 B29K309/08 B29K307/02 B29K705/00 B29L31/30
			TECHNICAL FIELDS SEARCHED (IPC) B29C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 May 2006	Carré, J

CATEGORY OF CITED DOCUMENTS

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E : earlier patent document, but published on, or after the filing date
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 38 1062

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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23-05-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1081154 A	31-08-1967	AT 267148 B	10-12-1968
		BE 676471 A	16-06-1966
		CH 417226 A	15-07-1966
		DE 1475079 A1	10-07-1969
		NL 6601833 A	16-08-1966

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5866272 A **[0004]**
- WO 0056541 A **[0006]**

Non-patent literature cited in the description

- Advanced Chemistry & Technology. Garden Grove **[0007]**